School of Physics

Devi Ahilya Vishwavidyalaya

Vigyan Bhavan, Khandwa Road Campus,

Indore-452001,M. P. INDIA

Syllabus
Ph.D. Course Work
PHYSICS

S. No.	Name of Subject	Credits
1.	Review of related literature	03
2.	Research Methodology	04
3.	Computer applications	03
4.	Subject Specific-I	03
5.	Comprehensive viva Voce	03
	Total Credits	16

Paper I: Review of related literature **Credits: 03**

1.Selection of topic for literature.
2.Chronological development of the topic.
3.Current trends and Future scope.

Paper II: **Research Methodology** **Credits: 03**

PHY-803:

Unit I- Structural studies 16 Lectures

Basic Materials Characterization Techniques: Principle, instrumentation and applications of the following techniques- X ray based techniques: X-ray diffraction (XRD) and X-ray absorption fine structure (XAFS), Optical Spectroscopy: UV-VIS and FTIR Spectroscopy, Photoelectron spectroscopy: X-ray photoelectron spectroscopy.

Unit II Magnetic measurements 17 Lectures

Magnetic and structural characterization using - Mössbauer spectroscopy, magnetic hysteresis measurements making use of conventional induction technique and vibrating sample magnetometer technique, determination of magnetic anisotropy using torque magnetometer and, magnetostriction measurements using stress dependence of hysteresis loop and small angle magnetization rotation method.

Unit III Free Electron Laser related measurement Techniques. 11 Lectures

Introduction of free electron laser, types of undulator, fabrication of undulator, field measurement of undulator, method for undulator field measurement.

Testing of fiber optic systems: optical power, power measurement, optical and electrical bandwidth, wavelength measurement, dispersion measurement bandwidth measurement, phase measurement, polarization measurement.

Books Recommended:

1. Practical fiber optics by bailey and wright, An imprint of Elsevier, Jordan Hill, Oxford in 2003.
2. Y. Li, B. Faatz and J. Pflueger, Magnet sorting for the XFEL hybrid undulator comparative

study, DESY Report, TESLA-FEL, August 2007.
3. Lectures on the Free Electron Laser Theory and Related Topics, by G. Dattoli.
4. Elements of X-ray Diffraction: B. D. Cullity, Addison Wesley Publishing Company Inc.
5. X-ray Spectroscopy, An Introduction: B. K. Agarwal, Springer Verlag, Berlin.
6. Applied Electron Spectroscopy for Chemical Analysis: H. Windawi and Floyd F. L. Ho, Wiley Interscience Publications.
7. Mössbauer Spectroscopy, V. G. Bhide.
8. Physics of Ferromagnetism: S. Chikazumi, Second Edition, Clarendon press, Oxford, 1997

Paper III Computer Applications Credits: 03 (24 T + 30 P)

PHY-805:

Unit I

Programming using C++. Numeric data type expression input /output, logical expression, selection control structure, loops, if, for, while and do-while.

Unit II

A. Matlab / Scilab.The basic features of Matlab / Scilab, viz., variables, function & arrays, scripts, and operations. Visualization, programming, problems based on interpolation, integration, and initial value problems.

B. Microsoft Excel /Open Office Calc The basic features of spreadsheets, arithmetic operations on grid cells, inbuilt mathematical and statistical functions, display of data as line graphs, histograms and charts. Applications in using numerical methods.

Unit III

Application of various software's including-graphics software, such origin etc. Data analysis software's and their application in research, linear and polynomial regression.

Books Recommended:

1. Turbo C++, Robert Lafore, Galgotia Publications Pvt. Ltd, ISBN 81-85623-22-8.
2. Programming and Problem Solving with C++, N. Dale and C. Weems, Jones and Bartlett Publication, ISBN 978-93-80108-50-6.
3. Numerical mathematical analysis: J. B. Scarborough.
4. First course in numerical analysis: A Raltson.
5. Numerical methods in Science and Engg: S Rajsekharan.
6. Numerical methods for Physics, Science and Engineering: J. H. Mathews, Tata McGraw Hill Publishers 1984.
7. Numerical Methods for Engineers, Steven C. Chapra and Raymond P. Canale, McGraw-Hill Book Company, ISBN-0-07-100412
8. Matlab by Rudra Pratap.

PHY-807: **Credits: 03**

Title of the paper: Nanostructures and Nanotechnology:

Overview and properties of nanoparticles: Size Dependence of Properties, Crystal Structures, Face-Centered Cubic Nanoparticles, Tetrahedral Bonded Semiconductor Structures, Lattice Vibrations, Energy Bands, Localized Particles, Excitons. Metal Nanoclusters, Magic Numbers, Geometric Structure, Electronic Structure, Magnetic Clusters, Semiconducting Nanoparticles, Optical Properties, Coulomb Explosion, Molecular Clusters.

Methods of Measuring Properties of nanostructures: Structure, Atomic Structures, Crystallography, Particle Size determination, Surface Structure, Microscopy, Transmission Electron Microscopy, Field Ion Microscopy, Scanning Microscopy, Infrared and Raman

Spectroscopy, Photoemission and X- Ray Spectroscopy, Magnetic Resonance. Method of Synthesis: RF Plasma, Chemical Methods, Thermolysis, Pulsed Laser Methods.

Vibrational and Electronic properties: Ionic, Covalent, inert gas solids, metals, Experimental observations of phonon modes, Vibrational, Raman, Infrared spectroscopy, Phonon confinement, Effect of dimension on lattice vibration and density of states, Effect of size on Debye frequency, melting temperature, specific heat, plasmons, phase transition, Effect of lattice parameter on electronic structure, measurements of electronic structure of nanoparticles.

Mechanical and magnetic properties: Mechanical and dynamical properties of nanosized devices: Nanopendulum, Nanometer string, Nanospring, Clamped beam. Magnetism in Nanostructures: Basics of Ferromagnetism, Effect of Bulk Nanostructuring of Magnetic Particles, Dynamics of Nanomagnets, Nanopore Containment of Magnetic Particles, Nanocarbon Ferromagnets, Giant and Colossal Magnetoresistance, Ferrofluids.

Quantum Wells, Wires, and Dots: Fabrication of Quantum Nanostructures, Size and Dimensionality Effects, Size Effects, Conduction Electrons and Dimensionality, Fermi Gas and Density of States, Potential Wells, Quantum wells and quasi−two−dimensional systems, Coupled wells and superlattices, Doped heterojunctions, Nanolithography Partial Confinement, Properties Dependent on Density of States, Excitons, Single-Electron Tunneling, Infrared Detectors, Quantum Dot Lasers.

Books Recommended:

1. The Physics and Chemistry of Nanosolids: Frank J. Owens, and Charles P. Poole Jr., Wiley Interscience, 2008.
2. Introduction to Nanotechnology, Charles P. Poole Jr., and Frank J. Owens, Wiley Interscience, 2006.
3. Chemistry of Advanced Materials, Edited L. V. Interrante, and M. J. Hampden-Smith Wiley –VCH, U. S. A 1998.
4. Transport in Nanostructures, D. K. Ferry and S. M. Goodnick, Cambridge University Press, 1997.

PHY-807: Subject Specific- I Credits: 03

Title of the paper: Condensed Matter Physics

Electron structure: Classification and bonding in solids, Free electron model, Drude Model, Sommerfeld model, Electron states in a periodic potential, Tight binding theory, Pseudo potentials, screening, band structure methods, Fermi surface, Surface effects, related experimental methods.

Lattice vibration: Introduction to lattice vibrations; lattice vibrations as collective motions of ions around their equilibrium positions. Dispersion relation: monoatomic and diatomic case; acoustical and optical branches; extension to the general case (3D solids) Phonon

specific heat in solid: Dulong-Petit law, Einstein model and Debye model. Thermal Conductivity as Elastic waves; Phonon gas Model, Thermal Expansion in Solids.

Magnetism: Magnetism in isolated ions, ions in crystals, and ions in magnetic fields. Diamagnetism, Paramagnetism, Pauli paramagnetism, ordered magnetic states, metastable magnetic states. Magnetic transitions. Superconductivity.

Phase Transitions: Ideal and interacting systems. Cooperative phenomenon. Symmetry/order-structure correspondence. Equilibrium vs. instability. Order parameter. Discontinuous and subtler phase transitions. Cross-transition continuity-behaviors of thermodynamic-functions and thermodynamic-potential. Latent heat. Specific heat jump. Superheating/super cooling and phase-coexistence. Lattice gas model. Dimensional constraints. Effects of an external field. Correlation lengths. Fluctuations of order parameter and critical behavior. Landau phenomenology and scaling.

Quantum nature of condensed Heliums and their melting curves; manifestation of Bose and Fermi statistics in ^{4}He and ^{3}He. Superfluidity due to Bose condensation and due to pairing. Mixtures of ^{3}He and ^{4}He. Novel mechanisms for cooling.

Books Recommended:

1. J. S. Blakemore, Solid State Physics, 2nd Ed., Saunders (1974).
2. C. Kittel, Introduction to Solid Stat Physics 1st ed. (Willey Eastern, 1953).
3. A. O. E. Animalu, Intermediate Quantum Theory of Crystalline Solids, (Prentice-Hall of India) (1978).
4. O. Madelung, Introduction to Solid State Theory, (Springer-Verlag 1978).
5. G. Grosso, and G. P. Parravicini, Solid State Physics (Elsevier, 2004).
6. G. D. Mahan, Many Particle Physics, (Plenum Press, 1990); L. Kantorovich, Quantum theory of the Solid State: An Introduction, (Kluwer, 2004).
7. N. W. Ashcroft and N. D. Mermin, Solid State Physics,

PHY-807: Subject Specific- I Credits: 03

Title of the paper: Nano-photonics

Photonic crystals and resonators, Photonic bandgap, Defects in photonic crystals, Surface plasmons, Surface plasmons in noble metals, Surface plasmon polaritons at plane interfaces. Introduction to Quantum computation from bits to Qbit, Multiple Qbits, Single Qbit gates, Multiple Qbit gates, Quantum circuits, Bell states, Quantum teleportation.

Quantum wells and Superlattices, Quantum well lasers, Vertical cavity surface emitting lasers, Quantum dot lasers.

Books Recommended:

1. Lukas Novotny & Bert Hecht, Principles of Nano-Optics, Cambridge University Press, New York, 2006.
2. P.N. Prasad, Nanophotonics, John-Wiley, New Jersey, 2004.

3. Photonic Crystals: Physics, Fabrication & Applications, K. Inoue & K. Ohtaka (Eds.), Springer-Verlag Berlin Heidelberg New York, 2004.
4. Micheal A. Nielsen & Isaac L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2002.
5. Dirk Bouwmeester, Artur Ekert, Anton Zeilinger (Eds.), The Physics of Quantum Informations, Quantum Cryptography, Quantum Teleportation, Quantum Computation, Springer-Verlag Berlin Heidelberg New York, 2001.

PHY-807: Subject Specific- I Credits: 03

Title of the paper: Physics of bulk and nano-materials

Lattice structure: Crystalline and amorphous state, Symmetry operations, Point groups, Crystal system, Types of lattices, Size Dependence of Properties, Lattice structure of bulk and Nanomaterials, Diffraction of x-rays by crystals, Bragg's law, Reciprocal lattice, Brillouin zone, Ionic, Covalent, Molecular and Hydrogen bonded crystals, Lattice energy of ionic crystals. Synthesis of bulk and Nanomaterials: Solid State reaction, Chemical Methods, Pulsed Laser Methods. Particle Size determination.

Lattice vibrations: Vibrations of lattices (mono, dia and polyatomic), acoustic and optical phonons, dispersion relation for one, two and three dimension crystals, Inelastic neutron scattering, Elastic properties of solids, Specific heat of solids, Einstein and Debye theory of specific heat, Anharmonic crystal interactions, Thermal expansion, Thermal conductivity, Effect of size on Debye frequency, melting temperature, specific heat, Raman effect, Energy Bands, Localized Particles, Excitons, Metal Nanoclusters, Magic Numbers, Geometric Structure.

Novel properties: Quantum Nanostructures, Size Effects, Dimensionality Effects, Density of States, Potential Wells, Quantum wells, Coupled wells and superlattices, Nanolithography, Partial Confinement, Plasma oscillations, Screening effects, Polaritons, Polarons, Optical and Dielectric Properties, Single-Electron Tunneling. Flux quantization, Para, Dia and ferro elasticity, electricity and ferromagnetism, High temperature superconductors, Giant and Colossal Magnetoresistance, Multi Ferroelectric materials.

Books Recommended:

1. Solid State Physics, J. J. Quinn, K. S. Yi, Springer-Verlag Berlin Heidelberg 2009.
2. Intermediate Quantum theory of Crystalline Solids, A. O. E. Animalu, Prentice−Hall of India private Limited, New Delhi 1977.
3. Introduction to Solid State Physics, C. Kittel, VIIIth Edition, John Wiley and Sons, New York, 2005.
4. Introduction to Nanotechnology, Charles P. Poole Jr., and Frank J. Owens, Wiley Interscience, 2006.
5. Solid State Physics, J. D. Patterson, and B. C. Bailey, Springer Berlin Heidelberg New York, 2007.